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FIRST-YEAR VEGETATION AFTER FIRE, RESEEDING, AND FERTILIZATION ON THE ENTIAT EXPERIMENTAL FOREST

by

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Abstract

Vegetative cover measurements were made on permanent belt transects during 1971 on four watersheds severely and uniformly burned in 1970 that received the following treatments: seeded and fertilized with 57 kg./ha. of nitrogen as ammonium sulfate; seeded and fertilized with 54 kg./ha. of N as urea; seeded only; and control (no seeding, no fertilizer). Results are a progress report of a study being conducted to evaluate regrowth and successional patterns of native species and to determine the success of erosion control seeding and fertilization using two different sources of N and one of sulfur.

Comparisons between seeded watersheds and the unseeded, unfertilized control indicate that erosion control seeding improved first-year vegetative cover by up to one-third. Of the seeded species, orchard grass, hard fescue, and timothy provided most of the first-year cover. Perennial rye and yellow sweetclover showed poor development.

Effectiveness of fertilizer was questionable the first year since total cover on the seeded-only watershed was nearly as great as on the watershed seeded and fertilized with ammonium sulfate and greater than on the watershed seeded and fertilized with urea. However, observations in the early summer of 1972 indicate that vegetal cover on the fertilized watersheds is substantially higher than on the control or seeded-only watershed. Also, vigor of seeded species appears to be much better on the fertilized watersheds.

Keywords: Soil-binding plants, fertilization (plants),
forest regeneration (artificial)

INTRODUCTION

Fire has played an important role in the development, maintenance, and perpetuation of most forested communities of the Pacific Northwest. The ponderosa pine (*Pinus ponderosa* Laws.) and Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) forests of north-central Washington are no exception. This region is highly susceptible to fire because of the hot, dry summer climate, steep topography, and explosive flammability of sclerophyllous understory vegetation. According to Keene (1940), fires have occurred on an average of every 18 years in the ponderosa pine zone of eastern Oregon. Daubenmire and Daubenmire (1968) found records of extensive fires in Washington and Idaho in 1910, 1916, 1931, and 1967.

After a severe forest wildfire, it appears desirable to establish vegetal cover as soon as possible to reduce soil erosion and restore nutrient cycles. Both objectives are important for maintaining productivity of forested ecosystems. However, the latter may be especially important because many of the nutrient elements once incorporated into plant and litter materials are converted to oxides upon combustion and scattered as ash. In this form they are susceptible to leaching and erosion loss from the ecosystem.

Native vegetation, particularly those species which sprout from underground organs, appears to regrow rapidly after fire (Weaver 1951, Daubenmire and Daubenmire 1968, Franklin and Dyrness 1969). Also, germination of snowbrush ceanothus (*Ceanothus velutinus* Dougl.) seed is apparently stimulated by fire.[1/]

Despite the apparent ability of native species to revegetate burned areas, the regrowth may be too slow or the density too sparse to provide immediate soil stability and restore nutrient cycles. For this reason, erosion control seeding procedures have been outlined (Friedrich 1947, Rummell and Holscher 1955, Lavin and Springfield 1955). The recommended procedure is to seed 5 to 10 kg. /ha. of grass and legume seed into the ashes in the late summer or fall after the fire. However, Orr (1970) found that seeding on snow in April by helicopter was successful on a South Dakota burn. He concluded that

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[1/] Henry John Gratkowski. Heat as a factor in the germination of seeds of *Ceanothus velutinus* var. *laevigatus* T & G. Unpubl. Ph.d. thesis, Oreg. State Univ., 122 p., 1962.

growth of native and seeded species effectively reduced overland runoff and soil erosion within one to four growing seasons after the fire. Seeded species comprised more than half the vegetal cover during the 4 years studied.

In an earlier study in Montana, Friedrich (1947) found that fall seeding after fire was most successful where the original forest cover was dense and was least successful on open sites with sparse forest cover. He concluded that high quantities of twigs and litter in the dense forest produced the greatest amount of ash and a more favorable seedbed. Also, prefire vegetation under dense timber was normally sparse, and regrowth after fire offered little or no competition to seeded species. In contrast, open sites were more densely occupied by grasses and shrubs not easily killed by fire. He also felt that there was less damage to understory species in open stands of timber because fires were not so hot as in dense stands. Thus, surviving native species were able to compete more strongly with seeded species.

Neither the regrowth of native species after fire in the ponderosa pine-Douglas-fir zone nor success of erosion control seeding and fertilization has been extensively studied in the Pacific Northwest. Our field observations indicate that seeding and fertilization efforts have met with uncertain success in the past. One reason for failures may be a deficiency of N and S in the soil (Klock, Geist, and Tiedemann 1971). Such deficiencies may be amplified by gaseous losses of N and S contained in plant litter. DeBell and Ralston (1970) estimate that 62 percent of the N in pine litter and leaf materials is released upon ignition. Also many species used for erosion control seeding are marginally suited for this purpose because they cannot withstand frost heaving in the early spring, rapid soil drying in late spring, nor high soil temperatures during the summer. The lack of information regarding vegetative succession and the variable success of erosion control seeding and fertilization has prompted us to initiate a study to:

(1) measure the rate of regrowth of native species and patterns of succession following wildfire,

(2) determine the success of seeding a prescribed erosion control seed-mix relative to regrowth of native vegetation,

(3) evaluate the effect of two different sources of N and one of S on regrowth of native species and growth and development of seeded species.

The 17,000-ha. Entiat fire of August 1970, which severely and uniformly destroyed the vegetation on the watersheds of the Entiat Experimental Forest and adjacent Brennegan Creek in approximately 15 hours, provides an ideal setting to evaluate vegetation recovery. Information reported in this paper is a progress report on the first-year vegetation recovery following fire, erosion control seeding, and erosion control seeding and fertilization.

THE STUDY AREA

The physical setting, climate, and vegetation of the Entiat Experimental Forest have been elaborated by Berndt (1971) and Klock (1971). Briefly, the watersheds are typical of ponderosa pine-Douglas-fir forests of the east slope of the Cascade Range. Topography is steep, rising from 550 to 2,100 m. above a glaciated valley in an overland distance of 5 to 6 km. Soils are coarse and deep, developing in coarse ash or pumice over granitic bedrock. Summers are hot and dry (18° to 19° C. mean monthly maxima in July and August), with only 10 percent of the 46 cm. of precipitation falling between June and September. Brennegan Creek, an adjacent watershed to the east, was included in the study; it has similar characteristics and was burned also.

For purposes of this study we feel it necessary to expand the vegetation description of Berndt. Prior to the fire, vegetation at the lower, more xeric sites (550- to 920-m. elevations) consisted of an overstory of ponderosa pine with an understory of bitterbrush (*Purshia tridentata* (Pursh) DC.)[2/] and serviceberry (*Amelanchier alnifolia* Nutt.). Arrowleaf balsamroot (*Balsamorhiza sagittata* (Pursh) Nutt.), bracken fern (*Pteridium aquilinum* (L.) Kuhn.), spreading dogbane (*Apocynum androsaemifolium* L.), and bluebunch wheatgrass (*Agropyron spicatum* (Pursh) Scribn. & Sm.) were prominent herbaceous species. This zone is probably representative of the *Pinus ponderosa/Purshia/Agropyron* habitat type of Daubenmire and Daubenmire (1968). At intermediate and higher elevations, 920 to 1,675 m., Douglas-fir became more prominent, often occurring in almost pure stands on moister sites. Lodgepole pine (*Pinus contorta* Dougl.) normally occurred only in small, dense thickets. However, the southwest slope of Fox Creek was an almost pure stand of "doghair" lodgepole pine.

[2/] Plants were identified by Drs. F. J. Hermann and Charles Feddema of the National Herbarium at Fort Collins, Colorado.

Snowbrush ceanothus, willow (*Salix* spp.) and Sitka alder (*Alnus sinuata* (Reg.) Rydb.) were common shrubs. Halfshrubs and low shrubs consisted primarily of Oregon boxwood (*Pachistima myrsinites* (Pursh) Raf.), birchleaf spiraea (*Spiraea betulifolia* Pall.), prince's pine (*Chimaphila umbellata* (L.) Bart.), and kinnikinnick (*Arctostaphylos uva-ursi* (L.) Spreng.). Of the herbaceous species, pinegrass (*Calamagrostis rubescens* Buckl.), Ross sedge (*Carex rossii* Boott), spiraea, dogbane, and bracken fern were prominent. The intermediate elevations are characteristic of the *Pseudotsuga menziesii/Calamagrostis rubescens* habitat type described by Daubenmire and Daubenmire (1968). At the highest elevations (over 1,770 m.), whitebark pine (*Pinus albicaulis* Engelm.) was commonly encountered.

METHODS

To evaluate natural vegetative regrowth and succession, the Fox Creek watershed (473 ha.) of the Entiat Experimental Forest was designated as the control. It remains roadless with no seeding or fertilization. Burns and McCree Creeks (564 and 514 ha., respectively), the other two Experimental Forest watersheds, and Brennegan Creek (740 ha.), an adjacent watershed, were seeded by fixed-wing aircraft with a mixture of 2.2 kg./ha. Latar orchardgrass (*Dactylis glomerata* L.), 1.1 kg./ha. durar hard fescue (*Festuca ovina* var. *duriuscula* (L.) Koch), 1.1 kg./ha. of Drummond timothy (*Phleum pratense* L.), 1.1 kg./ha. perennial ryegrass (*Lolium perenne* L.), and 1.1 kg./ha. yellow sweetclover (*Melilotus officinalis* (L.) Lam.). Burns Creek was fertilized by helicopter with 280 kg./ha. of ammonium sulfate (equivalent to 57 kg./ha. of elemental N). McCree Creek received 118 kg./ha. of urea (equivalent to 54 kg./ha. of elemental N). Brennegan Creek was not fertilized.

Foliar cover of each species was measured on permanent belt transects established midslope on the south- and west-facing aspects of each watershed. Transect dimensions are 2 ft. by 43.56 ft. (0.6 m. by 13.3 m.). Transects were established systematically from a random start at intervals of 180 m. between elevations of 1,700 and 730 m. Transect orientation conforms to the contour with steel posts used to mark head and tail stakes. Transects on Fox and Burns Creeks were established immediately following the fire in September 1970. Those on McCree and Brennegan Creeks were established in July and August 1971 at the time the first measurements were taken.

Vegetal cover was measured as a vertical projection of foliar material onto the ground surface for each species with a 1-ft. (0.3 m.) belt along both sides of a tape stretched between the stakes forming the transect. A 1.0-ft.^{2} (929 cm.^{2}) frame divided into 0.50, 0.25, 0.15, 0.10, and 0.05-ft.^{2} (464, 232, 139, 93, and 47-cm.^{2}, respectively) sections was used to reference cover measurements. Tree seedlings and snowbrush ceanothus seedlings were counted on the transect when cover estimates were made. To account for phenological differences, transects below 1,100 to 1,200 m. were measured between July 20 and August 10, 1971. Those above this elevation were measured between August 10 and September 1. Because selection of this elevation was controlled by accessibility, there is no assurance that the environment at one aspect and elevation of a watershed is precisely similar to that on any other watershed. However, the overall range in habitat types and the relationship between habitat type, elevation, and aspect are similar among watersheds.

Frequency was computed as a ratio of the number of transects on which a given species was found to the total number of transects. Results are a summary by watershed, aspect, elevation, class of plant, and species. No statistical tests of the data were performed.

RESULTS AND DISCUSSION

By the end of the first growing season after the fire, an average of 8.6 percent of the ground was covered by foliar material of native and seeded species. The most salient features of the first-year vegetation were the dominance of native species and the rapid development of orchardgrass (fig. 1). Although most of the native plants sprouted from rhizomes, lignotubers (basal buds of shrubs), bulbs, or other underground organs, annual plants were abundant on many of the lower elevation transects and the entire area abounded with snowbrush ceanothus seedlings from seed triggered by fire.

Burns Creek (seeded and fertilized with ammonium sulfate) displayed the greatest vegetative development of the four watersheds with a cover of 10.8 percent. Vegetative cover on Brennegan Creek (seeded-only) was 10.3 percent--surprisingly close to vegetation development on Burns Creek. Even though McCree Creek was fertilized with urea and seeded, vegetative cover was only 7.5 percent. Fox Creek, the control watershed, had the poorest vegetative cover of any watershed--5.6 percent.

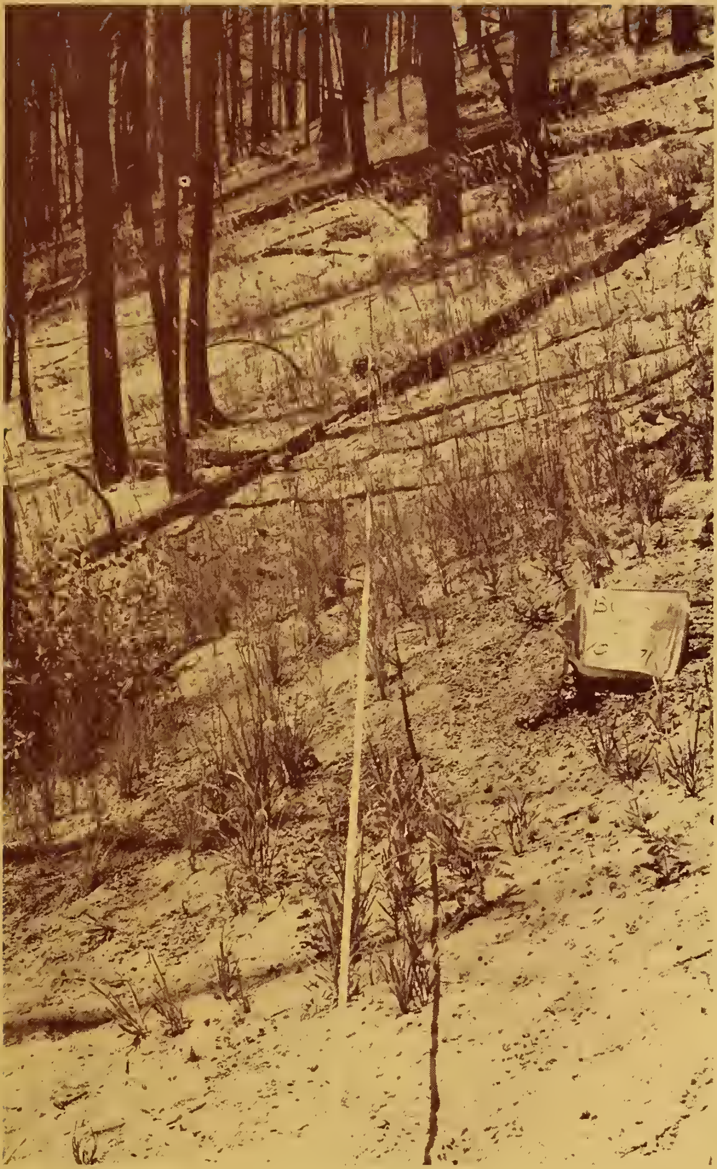

Figure 1.--*Typical first-year growth of native and seeded species. Prominent species are willow, pinegrass, and orchardgrass.*

South-facing slopes generally had the best cover of vegetation, averaging 10.0 percent compared with 6.7 percent on the west-facing slopes. Vegetative cover among watersheds was also more uniform on the south aspects than on the west, ranging from 8.8 percent to 11.7 percent (fig. 2). On the west aspects, cover varied from 2.0 percent on Fox Creek to 9.9 percent on Burns Creek.

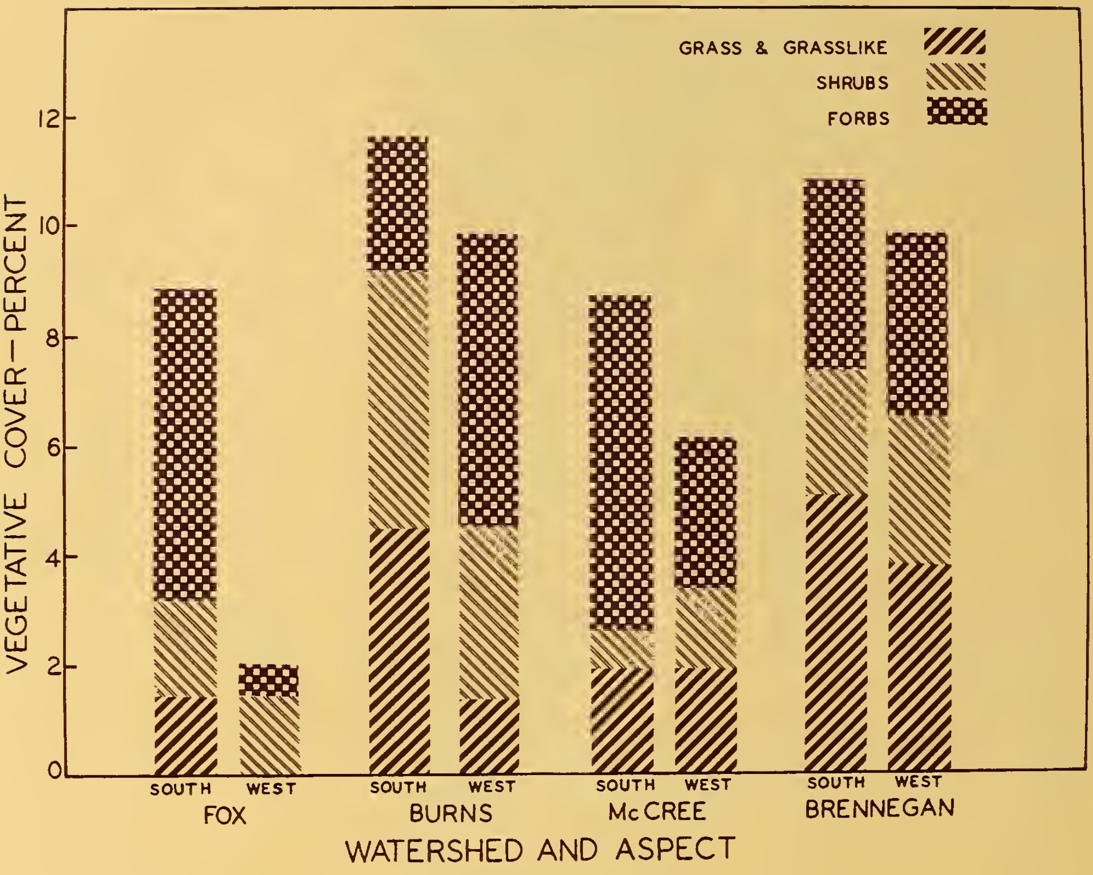

Figure 2.--*Vegetative cover of three classes of vegetation on south and west aspects of the four study watersheds.*

Understory vegetation on the west face of Fox Creek was probably sparse before the fire because much of this aspect was occupied by a dense stand of lodgepole pine (fig. 3). Also, bark was burned to the cambium on many stems, indicating that the fire reached extreme temperatures, possibly killing much of the understory vegetation.

Lower elevations of the watersheds had more vegetal cover (10.1 percent) than higher elevations (7.3 percent). Most of this difference occurred at Fox and McCree Creeks where cover at lower elevations was twice as great as that at higher elevations (fig. 4). Differences between elevations are probably the result of differences in species composition and differential stage of vegetation development. In addition, most of the area responsible for the sparse vegetal cover on the west aspect of Fox Creek was at higher elevations. In fact, the first transect at the upper end of the west aspect of Fox Creek had no vegetation.

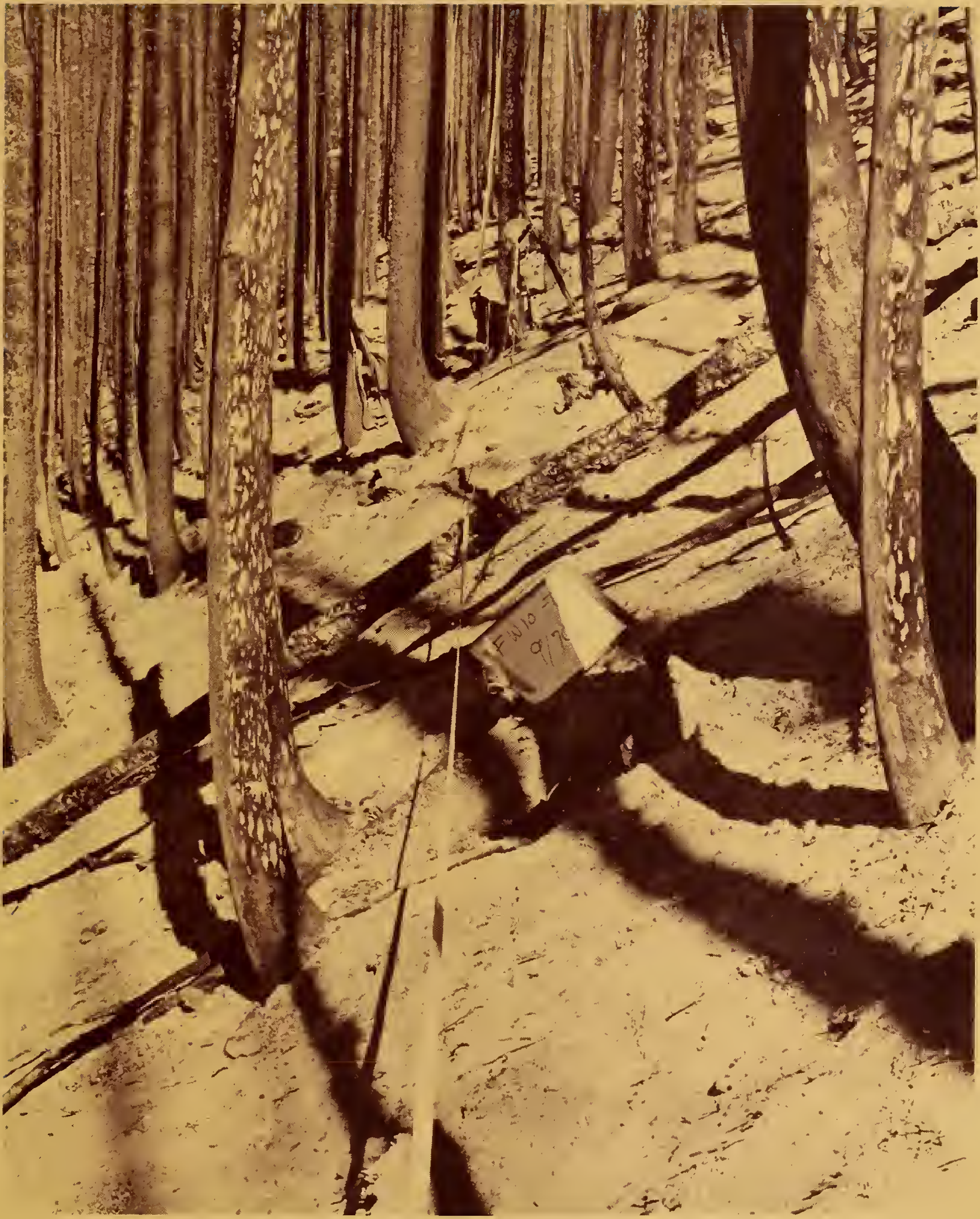

Figure 3.--*Transect on the west aspect of Fox Creek. The fire was so intense that bark was burned to the cambium of many stems.*

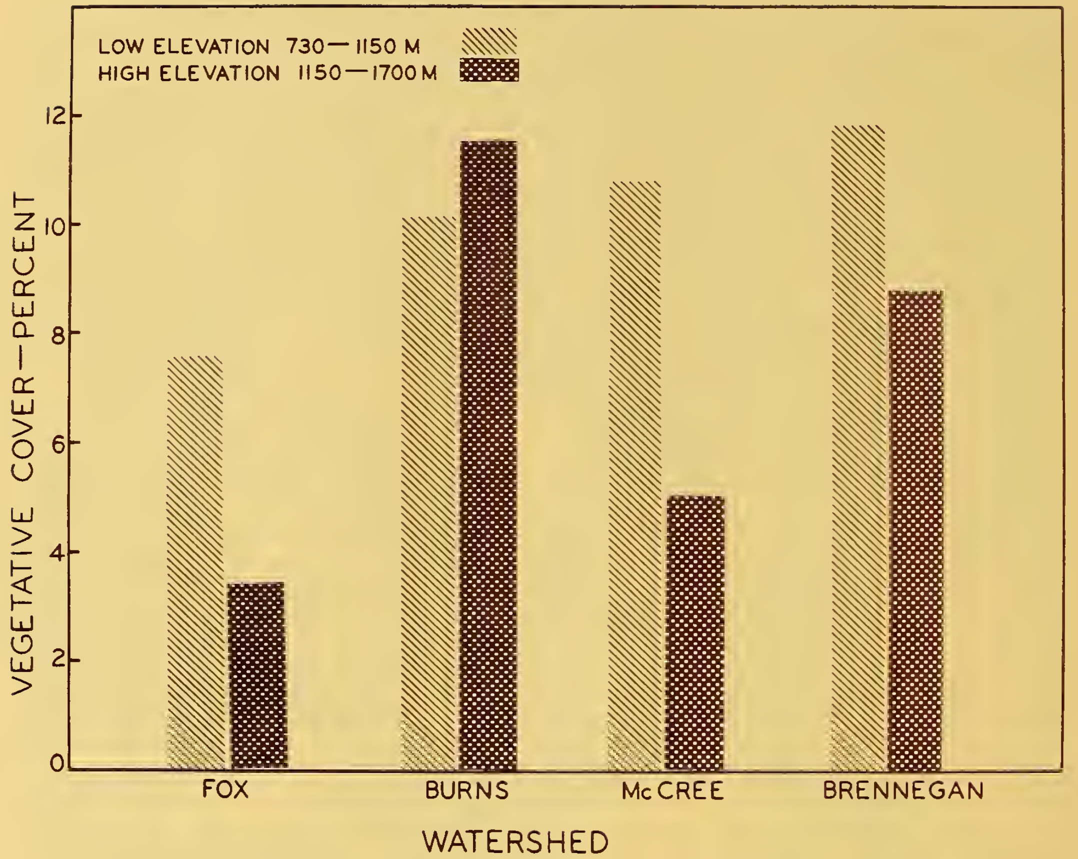

Figure 4.--*Total vegetative cover at low and high elevations on the four study watersheds.*

Forbs were the most abundant first-year vegetation on the watersheds, averaging 3.7-percent cover compared with 2.3- and 2.6-percent cover for grass and grasslike plants and shrubs, respectively.

However, the amount of vegetative cover provided by each class of vegetation and the proportion of the total vegetative cover that each class comprised varied greatly among watersheds and between aspects. Forbs attained their maximum ground coverage on McCree Creek (fig. 2), whereas grass and grasslike plants and shrubs had the greatest foliar coverage on Brennegan and Burns Creeks, respectively. On Fox Creek the cover of forbs on the west slope of 0.4 percent contrasted markedly with 5.7 percent on the south slope. Cover of the grass and grasslike class also varied widely, from 0.02 percent on the west aspect of Fox Creek to over 5 percent on the south face of Brennegan Creek. The lowest shrub cover (0.7 percent) was observed on the south slope of McCree Creek. Shrub cover was highest on the south slope of Burns Creek (4.7 percent).

Bracken fern, spreading dogbane, and fireweed (*Epilobium angustifolium* L.) were the dominant forbs (table 1), comprising 70, 89, 76, and 59 percent of the total forb cover on Fox, Burns, McCree, and Brennegan Creeks, respectively. Bracken fern was encountered on 24 to 40 percent of the transects and had the highest vegetative cover (1.1 to 2.2 percent) of any of the forbs.

Of the native grass and grasslike plants, the most abundant were pinegrass and Ross sedge. Vegetal cover of pinegrass varied from 0.2 percent on McCree Creek to 1.1 percent on Brennegan Creek. Ross sedge was the only grasslike plant encountered; despite its occurrence on 30 to 60 percent of the plots, it provided only 0.03- to 0.15-percent vegetal cover.

Sprouts of shrubs provided most of the first-year cover for this class of vegetation. Snowbrush ceanothus, the dominant shrub, was encountered on 71 to 92 percent of the transects and provided 0.53- to 1.35-percent cover. In addition to the sprouts, snowbrush ceanothus seedlings were abundant. These averaged 7.4/m.^{2}, ranging from 5.5/m.^{2} on McCree Creek to 10.4/m.^{2} on Fox Creek. Many willow and Sitka alder shrubs had sprouted within 1 month after fire; and by the time transects were evaluated, their foliage covered an average of 0.49 and 0.20 percent, respectively, of the ground on the four watersheds. Birchleaf spiraea, a halfshrub, was encountered on 68 to 88 percent of the transects and provided 0.31- to 0.82-percent cover.

When compared with total vegetal cover, the first-year performance of seeded species appears to be poor. On the seeded watersheds, foliar cover of seeded species was only 18 to 32 percent of the total cover (table 2). However, when compared with the vegetative cover provided by grasses and grasslike plants, seeded grasses made up a large portion (64 to 78 percent) of that class of vegetation. Orchardgrass, in addition to being the most prominent seeded grass, was the most ubiquitous grass on the seeded watersheds. It was found on 77 to 80 percent of the transects and covered 1.22 to 2.24 percent of the ground. Hard fescue plants, although found on 53 to 92 percent of the transects, were small and only provided 0.21- to 0.61-percent cover. Timothy did not develop as well as orchardgrass and hard fescue. Nonetheless, it provided between 0.06- and 0.36-percent ground cover and was encountered on more than half the transects. Perennial ryegrass and yellow sweetclover performed poorly compared with the other three species. Vegetative cover ranged from 0.01 to 0.06 percent and frequency, from 13 to 38 percent.

Table 1.--*Cover and frequency of three classes of first-year understory vegetation by species*

Species	Fox		Burns		McCree		Brennegan	
	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency
Shrubs	- - - - - - - - - -	- - - - - - - - - -	- - - - - - - - - -	- - - - Percent	- - - - - - - - - -	- - - - - - - - - -	- - - - - - - - - -	- - - - - - - - - -
Ceanothus velutinus	0.73	91	1.35	93	0.53	71	1.22	92
Salix spp.	.45	6	.69	30	.10	25	.74	25
Alnus sinuata	.03	12	.65	7	.10	18	.02	4
Spiraea betulifolia	.36	73	.82	70	.31	68	.52	88
Pachistima myrsinites	.05	32	.29	23	.01	14	.01	21
Arctostaphylos uva-ursi	0	0	(1/)	7	.03	4	.02	21
Chimaphila umbellata	0	0	.24	13	0	0	0	0
Vaccinium spp.	.01	18	0	0	0	0	0	0
Purshia tridentata	0	0	0	0	(1/)	11	.01	8
Prunus emarginata	0	0	0	0	(1/)	7	(1/)	8
Rubus spp.	0	0	0	0	0	0	.01	4
Amelanchier alnifolia	(1/)	3	.01	13	0	0	0	0
Ribes spp.	(1/)	9	0	0	0	0	0	0
Total shrubs	1.64	--	4.03	--	1.09	--	2.55	--
Grasses and grasslike								
Calamagrostis rubescens	.67	41	1.03	33	.16	29	1.08	62
Carex rossii	.03	59	.05	43	.07	57	.15	29
Dactylis glomerata	.03	26	1.56	80	1.22	79	2.24	92
Phleum pratense	.01	15	.12	53	.06	57	.36	63
Festuca ovina	.01	23	.21	53	.21	75	.61	92
Lolium perenne	(1/)	9	.01	13	.01	18	.06	38
Poa sandbergii	0	0	(1/)	3	0	0	(1/)	4
Agropyron spicatum	0	0	(1/)	13	.04	21	0	0
Bromus carinatus	.02	6	0	0	.01	4	0	0
Oryzopsis exigua	0	0	0	0	.01	7	0	0
Stipa occidentalis	0	0	(1/)	3	.08	18	0	0
Bromus tectorum	0	0	(1/)	10	.06	4	(1/)	8
Total grasses and grasslike	.78	--	2.99	--	1.92	--	4.50	--

Forbs								
Pteridium aquilinum	1.59	24	1.65	40	2.18	39	1.15	38
Apocynum androsaemifolium	.47	26	1.41	73	1.06	82	.58	46
Epilobium angustifolium	.19	81	.31	73	.16	71	.18	54
E. paniculatum	(1/)	3	.01	10	.01	14	.01	4
Collinsia parviflora	.06	24	.03	27	.08	32	.08	25
Cryptantha simulans	.06	24	.09	23	.21	36	.33	38
Hieracium cynoglossoides	.01	9	.01	10	(1/)	4	.03	17
H. albiflorum	.01	6	.01	3	0	0	.01	4
Mentzelia dispersa	(1/)	3	.01	3	.22	25	.03	4
Gayophytum nuttallii	.06	21	.06	37	.22	39	.05	29
Achillea millefolium	(1/)	12	.01	7	.05	25	.02	25
Collomia grandiflora	0	0	0	0	.02	11	(1/)	4
Collomia tinctoria	.01	9	0	0	.08	25	(1/)	12
Balsamorhiza sagittata	0	0	0	0	.03	4	0	0
Phacelia hastata	.05	32	(1/)	3	.04	11	(1/)	8
Zigadenus paniculatus	0	0	0	0	.01	4	(1/)	4
Arnica cordifolia	.01	9	0	0	.02	4	.18	8
Lomatium brandegei	0	0	.02	3	.01	8	.01	12
Lupinus sulphureus	.35	21	0	0	.02	7	.29	25
Calochortus lyalli	0	0	0	0	(1/)	4	(1/)	8
Montia perfoliata	0	0	(1/)	7	.05	14	.01	12
Malvastrum spp.	(1/)	3	0	0	0	0	0	0
Anaphalis margaritacea	(1/)	3	(1/)	3	(1/)	7	(1/)	12
Luina nardosmia	.31	6	0	0	0	0	0	0
Senecio integerrimus	0	0	0	0	0	0	(1/)	8
Smilacina racemosa	(1/)	3	0	0	0	0	0	0
Sedum stenopetalum	0	0	.01	3	0	0	0	0
Erythronium spp.	0	0	(1/)	3	0	0	0	0
Hydrophyllum capitatum	0	0	0	0	0	0	.04	8
Melilotus officinalis	(1/)	6	.01	30	.01	32	.04	33
Eriogonum spp.	0	0	(1/)	3	(1/)	4	.12	25
Allium spp.	0	0	0	0	(1/)	4	0	0
Clarkia rhomboidea	0	0	0	0	0	0	.02	17
Polygonum majus	.01	6	0	0	(1/)	14	(1/)	8
Arenaria macrophylla	.01	15	.08	20	(1/)	11	0	0
Erysimum asperum	0	0	(1/)	3	.01	4	.04	8
Conyza canadensis	(1/)	3	(1/)	3	0	0	(1/)	3
Clematis ligusticifolia	.01	8	0	0	0	0	0	0
Unidentified forbs	(1/)	--	0	--	0	--	(1/)	--
Total forbs	3.24	--	3.79	--	4.48	--	3.24	--
Total, all classes	5.65	--	10.81	--	7.49	--	10.29	--

1/ Vegetative cover less than 0.01 percent.

NOTE: Individual values do not add up to totals shown because of rounding and because of exclusion of values less than 0.01 percent.

Table 2.--*First-year vegetative cover of seeded species*

Species	Fox	Burns	McCree	Brennegan
	- - - - - - -	*Percent*	- - - - - - -	
Dactylis glomerata	0.04	1.56	1.22	2.24
Festuca ovina var. *duriuscula*	.01	.21	.21	.61
Phleum pratense	.01	.12	.06	.36
Lolium perenne	(1/)	.01	.01	.06
Melilotus officinalis	(1/)	.01	.01	.04
Total cover seeded species	.06	1.91	1.51	3.30
Percentage of total vegetal cover	1.0	17.6	20.1	32.1
Percentage of grass and grasslike class of vegetation comprised by seeded grasses	7.7	63.5	77.7	72.6

[1/] Vegetative cover less than 0.01 percent.

NOTE: Individual values do not add up to totals shown because of rounding and because of exclusion of values less than 0.01 percent.

All five seeded species were found in Fox Creek, apparently as a result of drift when seed was applied. However, in this watershed they comprised only 1 percent of the total vegetal cover.

The abundance of snowbrush ceanothus, willow, fireweed, birchleaf spiraea, and pinegrass conforms to results of other workers (Larsen 1929, Weaver 1951, Neiland 1958, and Mueggler 1965). According to Mueggler, a single broadcast burn causes a significant increase in the frequency of these species compared with an undisturbed forest. Although we observed that spreading dogbane and bracken fern had high frequencies and provided striking amounts of cover, Mueggler concludes that fire does not influence the frequency of these two species.

Of the five seeded species, establishment and development of orchardgrass and hard fescue conformed most closely to the performance description provided by Hafenrichter et al. (1968).

Orchardgrass is classified as a rapidly developing, long-lived grass, whereas hard fescue is a slowly developing, fine-leaved grass particularly well suited for erosion control. Despite its sparse vegetative cover, the occurrence of hard fescue on 53 to 92 percent of the transects on seeded watersheds supports the description.

First-year performance of timothy is difficult to evaluate in terms of other research--Hafenrichter et al. (1968) classify it as a meadow grass--and yet it appears to establish and grow well on harsh sites such as those on the Entiat watersheds. Orr (1970) observed that timothy became established more rapidly than smooth brome or Kentucky bluegrass and maintained dominance during a 4-year study. Timothy was not tested with orchardgrass in Orr's study. Perhaps orchardgrass suppressed the growth of timothy in our study. The poor first-year establishment and growth of perennial ryegrass was surprising, since it is described as a rapidly developing, short-lived grass. The poor performance of yellow sweetclover was anticipated, since it is best adapted to irrigated situations and to soil types other than those encountered on the Entiat Experimental Forest. Also because of their low frequency, it is doubtful that the vegetative cover of perennial ryegrass or yellow sweetclover will increase substantially in subsequent years.

Many species displayed distinct aspect and elevational distributions which give clues to the reasons for differences in total vegetal cover between aspects and elevations. Alder was prominent among shrubs in its preference for the west aspect at higher elevations (table 3). Willow was most abundant on west slopes at lower elevations. Snowbrush cover was nearly three times greater on south aspects than west and had slightly greater vegetative development at upper elevations.

The difference in cover and frequency between aspects was striking for pinegrass--on south-facing slopes, cover and frequency were 1.25 and 63 percent, respectively, compared with 0.15 and 16 percent on west aspects. Pinegrass, however, displayed no elevation preference.

Bracken fern reached its greatest cover development on south aspects at lower elevations. Cover and frequency were twice as great on south as on west aspects and five times greater at low than at high elevations. Both vegetative cover and frequency of fireweed were greatest on the south aspects at higher elevations.

Table 3.--*Vegetative cover and frequency distribution by aspect and elevation*

Species	Aspect				Elevation			
	South		West		Low		High	
	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency
	Percent							
Shrubs								
Purshia tridentata	(1/)	7	0	0	0.01	9	0	0
Ribes spp.	(1/)	5	0	0	(1/)	2	(1/)	3
Ceanothus velutinus	1.40	92	.46	82	.82	94	1.05	80
Pachistima myrsinites	.16	30	.02	18	.01	12	.16	34
Rubus spp.	0	0	(1/)	2	(1/)	2	0	0
Alnus sinuata	(1/)	2	.42	20	.01	5	.38	15
Salix spp.	.32	15	.66	27	.73	24	.26	18
Chimaphila umbellata	(1/)	5	.12	2	(1/)	2	.11	5
Arctostaphylos uva-ursi	(1/)	5	.03	9	.03	11	(1/)	3
Spiraea betulifolia	.52	72	.48	77	.36	76	.63	72
Vaccinium spp.	0	0	.01	2	(1/)	2	.01	8
Amelanchier alnifolia	(1/)	7	(1/)	2	(1/)	9	0	0
Prunus emarginata	(1/)	3	(1/)	4	0	0	(1/)	6
Total shrubs	2.40	--	2.20	--	1.97	--	2.60	--
Grasses and grasslike								
Poa sandbergii	(1/)	3	0	0	(1/)	2	(1/)	2
Bromus carinatus	.02	5	0	0	(1/)	2	.01	3
Calamagrostis rubescens	1.25	63	.15	16	.75	51	.70	31
Festuca ovina	.17	60	.30	55	.30	55	.17	61
Carex rossii	.05	60	.09	41	.08	62	.06	41
Dactylis glomerata	1.40	67	.92	66	1.01	65	1.31	67
Phleum pratense	.09	48	.16	41	.19	36	.06	52
Lolium perenne	.01	22	.02	14	.03	18	.01	18
Agropyron spicatum	.01	10	.01	7	.02	11	(1/)	7
Stipa occidentalis	.03	5	.01	5	.04	11	0	0
Bromus tectorum	.03	5	(1/)	5	.03	5	(1/)	5
Oryzopsis exigua	(1/)	2	(1/)	2	(1/)	4	0	0
Total grasses and grasslike	3.06	--	1.66	--	2.45	--	2.32	--

Forbs								
Balsamorhiza sagittata	.01	2	0	0	.01	2	0	0
Zigadenus paniculatus	(1/)	3	0	0	(1/)	4	0	0
Malvastrum spp.	(1/)	2	0	0	0	0	(1/)	2
Luina nardosmia	.17	3	0	0	0	0	.17	3
Smilacina racemosa	(1/)	2	0	0	0	0	(1/)	2
Pteridium aquilinum	2.27	48	1.00	20	2.99	60	.45	11
Epilobium angustifolium	.29	68	.13	61	.18	69	.24	61
Mentzelia dispersa	.11	12	.01	5	.13	16	(1/)	2
Gayophytum nuttallii	.15	40	.04	21	.17	47	.03	16
Collomia grandiflora	.01	3	(1/)	4	.01	7	0	0
Collinsia parviflora	.08	3	.05	20	.11	41	.02	13
Sedum stenopetalum	0	0	.01	2	0	0	.01	2
Erythronium spp.	0	0	(1/)	2	0	0	(1/)	2
Hydrophyllum capitatum	0	0	.02	4	.01	2	(1/)	2
Lomatium brandegei	0	0	.01	11	.01	9	.01	2
Allium spp.	0	0	(1/)	2	(1/)	2	0	0
Clarkia rhomboidea	0	0	.01	7	.01	5	(1/)	2
Erysimum asperum	0	0	.02	7	.02	5	(1/)	2
Conyza canadensis	0	0	(1/)	5	(1/)	4	(1/)	2
Clematis ligusticifolia	0	0	(1/)	5	(1/)	2	(1/)	3
Eriogonum spp.	(1/)	2	.05	12	.05	9	(1/)	5
Lupinus sulphureus	.12	12	.22	14	.15	20	.18	7
Arenaria macrophylla	.01	5	.04	20	(1/)	7	.04	16
Cryptantha simulans	.17	32	.16	27	.31	47	.03	13
Apocynum androsaemifolium	.86	68	.90	46	1.02	56	.75	56
Epilobium paniculatum	.01	8	(1/)	7	.01	13	(1/)	3
Hieracium cynoglossoides	.01	8	.01	11	.02	14	.01	5
H. albiflorum	.01	5	.01	2	.01	4	.01	3
Arnica cordifolia	.07	3	.02	7	.01	5	.07	5
Calochortus lyalli	(1/)	3	(1/)	8	(1/)	5	0	0
Montia perfoliata	.01	7	.01	9	.03	16	0	0
Anaphalis margaritacea	(1/)	5	(1/)	7	(1/)	11	(1/)	2
Phacelia hastata	.04	15	.01	14	.03	18	.02	11
Senecio integerrimus	(1/)	2	(1/)	2	(1/)	2	(1/)	2
Collomia tinctoria	.04	13	.01	9	.04	14	.01	8
Achillea millefolium	.03	22	.01	11	.03	27	.01	7
Melilotus officinalis	.01	32	.02	16	.01	25	.02	23
Polygonum majus	(1/)	5	(1/)	9	(1/)	9	(1/)	5
Unidentified forbs	(1/)	--	(1/)	--	(1/)	--	(1/)	--
Total forbs	4.48	--	2.77	--	5.37	--	2.08	--
Total, all classes	9.94	--	6.63	--	9.79	--	7.00	--

1/ Vegetative cover less than 0.01 percent.

NOTE: Individual values do not add up to totals shown because of rounding and because of exclusion of values less than 0.01 percent.

Annual species, such as gilia (*Collomia grandiflora* Dougl. ex Lindl.), littleflower collinsia (*Collinsia parviflora* Lindl.), and cryptantha (*Cryptantha simulans* Greene), achieved their maximum cover at the lower elevations. Vegetative cover of annual plants was 0.87 percent there compared with 0.09 percent at higher elevations. Annuals, however, appeared to show no aspect affinity.

Of the seeded grasses, hard fescue and timothy showed the greatest cover development on west aspects at lower elevations; whereas orchardgrass appeared to grow equally well on both aspects and at low and high elevations.

Some species were restricted in their distribution between elevations and aspects. Bitterbrush, Sandberg bluegrass (*Poa sandbergii* Vasey), mountain brome (*Bromus carinatus* Hook. & Arn.), arrowleaf balsamroot, and luina (*Luina nardosmia* (Gray) Cronq.) were encountered only on the south aspect. Thimbleberry (*Rubus* spp.), huckleberry (*Vaccinium* spp.), stonecrop (*Sedum stenopetalum* Pursh), waterleaf (*Hydrophyllum capitatum* var. *capitatum* Hook), and lomatium (*Lomatium brandegei* (Coult. & Rose) Macbr.) were found only on west-facing slopes.

Species confined to low elevations included western needlegrass (*Stipa occidentalis* Thurb.), bitterbrush, serviceberry, arrowleaf balsamroot, and miner's lettuce (*Montia perfoliata* (Donn) Howell). Bitter cherry (*Prunus emarginata* (Dougl.) Walpers) and luina occurred only at higher elevations.

Differences in total vegetative cover between aspects appear to be mainly the result of higher cover and frequency on the south aspects of snowbrush ceanothus, pinegrass, and bracken fern. Greater abundance of willow, bracken fern, and annual forbs at low elevations probably explains the greater cover found there than at higher elevations. Also, sparse vegetal cover on the west aspect of Fox Creek at higher elevations was a primary factor in elevation differences.

Mueggler observed an affinity of alder for north slopes, whereas snowbrush ceanothus and bracken fern preferred southerly exposures Distributions observed on the Entiat watersheds are similar, with alder showing a preference for the relatively cooler, more mesic west exposure, and snowbrush and bracken fern an affinity for the more xeric south slopes. Mueggler found development of dogbane to be greatest on south exposures but apparently detected no aspect preference for pinegrass. Results of the Entiat study were in direct contrast--dogbane showed no aspect differences but pinegrass had a strong affinity for south slopes.

We found some elevation differences which correspond with those of Mueggler and some that were contrasting. Willow and western yarrow (*Achillea millefolium* L.) reached their greatest development at elevations below 1,100 m. in both studies. We found that bracken fern was most abundant at lower elevations, and pinegrass cover and frequency were similar at both elevations. In Mueggler's study, bracken was apparently the same at low (less than 1,100-m.) and high (greater than 1,280-m.) elevations, and pinegrass preferred low elevations.

Unidentified tree seedlings were encountered on nearly every transect, averaging 0.78 seedling/m.^{2}. Burns Creek had the lowest density of tree seedlings (0.3/m.^{2}), and Fox Creek had the highest (1.5/m.^{2}).

CONCLUSIONS

Comparison of the total vegetal cover on Fox Creek (control) with that on the seeded watersheds and the fact that seeded grasses comprised 64 to 78 percent of the grass and grasslike plants indicate that seeding is an effective means of supplementing regrowth of native species to provide vegetal cover after wildfire.

According to Friedrich's (1947) description, a site such as that on the west face of Fox Creek (unseeded, unfertilized watershed) is the type best suited for successful seeding. Comparison of the vegetal cover on similar sites in seeded watersheds tends to support this conclusion. Whereas the stream bottom and the west slope of Fox Creek were nearly devoid of vegetation, areas of the same habitat type with dense residual overstory of dead trees and slopes of 30 to 40 percent in the seeded watersheds supported vigorous stands of seeded species. For example, on one transect in McCree Creek, cover of orchardgrass was 8.5 percent. Thus, it is likely that vegetative cover of Fox Creek could have been improved by seeding.

The fact that McCree Creek had the lowest cover of seeded species of the three seeded watersheds may have been the result of a reduced seeding rate. In designing the study, we intended to seed only the upper two-thirds of McCree Creek so we could determine the effect of urea fertilization on regrowth of the native species on the lower third. Drift of seed into the lower third of the watershed was great enough to substantially reduce the seeding rate on the upper two-thirds.

Effectiveness of fertilizer treatments in promoting growth the first year is questionable at this point. Despite the greater total vegetal cover on Burns Creek (fertilized with ammonium sulfate), seeded species comprised a greater portion (32 percent) of the total vegetal cover in Brennegan Creek (unfertilized) than in any other watershed. These results are contrary to those of a pot study by Klock et al. (1971), which showed that orchardgrass yields on these soils fertilized with 50 and 200 p. p. m. of ammonium sulfate were two and seven times greater, respectively, than without fertilization. Perhaps the rate of fertilization was too low to give a detectable response the first year.

Vegetative composition is an important factor contributing to differences in total vegetal cover between Burns and McCree, the two fertilized watersheds. Whereas they both displayed about the same vegetal cover of seeded species, native grasses, and forbs, Burns Creek had a much higher percentage of shrubs than McCree Creek.

Observations in the early summer of 1972 indicated that the vegetal cover of Burns and McCree Creeks was substantially higher than on Fox or Brennegan Creeks. Also, vigor of seeded species appeared to be much greater on the fertilized watersheds than on unfertilized Brennegan Creek.

Although we have no way of assessing the benefit of seeding and fertilization relative to the cost of application of $38, 400 for the three watersheds (Perkins et al. 1971), observations indicate that seeded grasses helped reduce soil erosion resulting from overland flow during high intensity summer storms (fig. 5).

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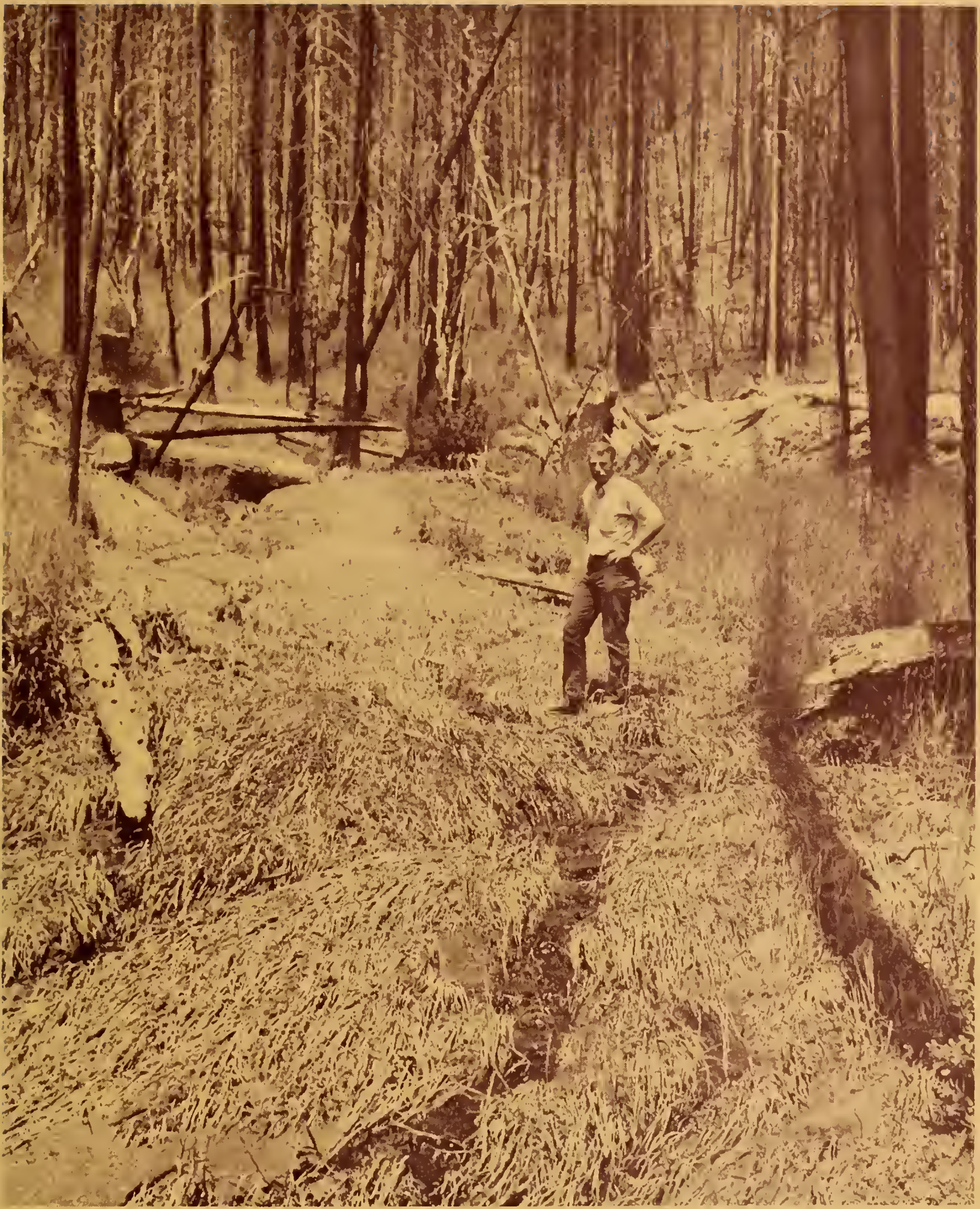

Figure 5.--*Vegetal cover resulting from seeding reduced channel scouring during a high-intensity rainstorm.*

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